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THE UNITED STATES
STRATEGIC BOMBING SURVEY

Reports Pacific war no. 28

ISHIKAWAJIMA AIRCRAFT INDUSTRIES COMPANY, LTD.

(Ishikawajima Koku Kogyo Kabushiki Kaisha)

CORPORATION REPORT No. XIII

(Engines)

AIRCRAFT DIVISION
Dates of Survey:
26 – 27 November 1945
Date of Publication:
1 November 1946

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This report was written primarily for the use of the United States Strategic Bombing Survey in the preparation of further reports of a more comprehensive nature. Any conclusions or opinions expressed in this report must be considered as limited to the specific material covered and as subject to further interpretation in the light of further studies conducted by the survey.

FOREWORD

The United States Strategic Bombing Survey was established by the Secretary of War on 3 November 1944, pursuant to a directive from the late President Roosevelt. Its mission was to conduct an impartial and expert study of the effects of our aerial attack on Germany, to be used in connection with air attacks on Japan and to establish a basis for evaluating the importance and potentialities of air power as an instrument of military strategy, for planning the future development of the United States armed forces, and for determining future economic policies with respect to the national defense. A summary report and some 200 supporting reports containing the findings of the survey in Germany have been published.

On 15 August 1945, President Truman requested that the survey conduct a similar study of the effects of all types of air attack in the war against Japan, submitting reports in duplicate to the Secretary of War and to the Secretary of the Navy. The officers of the survey during its Japanese phase were:

Franklin D'Olier, Chairman.
Paul H. Nitze, Henry C. Alexander, Vice Chairmen.
Harry L. Bowman,
J. Kenneth Galbraith,
Rensis Likert,
Frank A. McNamee, Jr.,
Fred Searles, Jr.,
Monroe E. Spaght,
Dr. Lewis R. Thompson,
Theodore P. Wright, Directors.
Walter Wilds, Secretary.

The survey's complement provided for 300 civilians, 350 officers, and 500 enlisted men. The military segment of the organization was drawn from the Army to the extent of 60 percent, and from the Navy to the extent of 40 percent. Both the Army and the Navy gave the survey all possible assistance in furnishing men, supplies, transport, and information. The survey operated from headquarters established in Tokyo early in September 1945, with subheadquarters in Nagoya, Osaka, Hiroshima, and Nagasaki, and with mobile teams operating in other parts of Japan, the islands of the Pacific, and the Asiatic mainland.

It was possible to reconstruct much of wartime Japanese military planning and execution, engagement by engagement, and campaign by campaign, and to secure reasonably accurate statistics on Japan's economy and war-production, plant by plant, and industry by industry. In addition, studies were conducted on Japan's over-all strategic plans and the background of her entry into the war, the internal discussions and negotiations leading to her acceptance of unconditional surrender, the course of health and morale among the civilian population, the effectiveness of the Japanese civilian defense organization, and the effects of the atomic bombs. Separate reports will be issued covering each phase of the study.

The survey interrogated more than 700 Japanese military, Government, and industrial officials. It also recovered and translated many documents which not only have been useful to the survey, but also will furnish data valuable for other studies. Arrangements have been made to turn over the survey's files to the Central Intelligence Group, through which they will be available for further examination and distribution.

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Ishikawajima Aircraft Industries Co., Ltd.

THE CORPORATION AND ITS IMPORTANCE IN THE AIRCRAFT INDUSTRY

INTRODUCTION

The Ishikawajima Aircraft Industries Co., Ltd. (Ishikawajima Kōkū Kogyo K K) was one of four Japanese companies which made the Ha–35 (Sakae 10-, 20-, and 30-series) engines used to power the Kate, Zeke, Rufe, Lily, Oscar, and Irving airplanes. In 1944, the peak year of Japanese aircraft engine production in general and Ha–35 engines in particular, Ishikawajima's output was 2.5 percent of the total and 10.9 percent of the total Ha–35 engines produced.

The company was founded in 1937 as a branch of the Ishikawajima Shipbuilding Co. (Ishikawajima Zosenjo). Initially this aircraft branch made minor aircraft engine component parts. In 1937 and 1938 it expanded its parts activities to include fabrication and final engine assembly.

The main Tomioka plant, in the Isogo Ward of Tomioka, a suburb of Yokohama, was planned late in 1937 and the foundry of this works was completed in September 1938. The original plan had been to make components for the Tempu and Jimpu engines for trainer planes. Beginning in 1939, however, parts were made for the Kinsei and Kasei engines.

Construction of the Tomioka machine shops was completed early in 1941. This was the company's largest expansion project, intended for both production and repair of Sakae engines for the Navy and general repair of other engine types.

The first repair was carried out in December 1940 and the first new engine was assembled in December 1941. The Tomioka plant was Ishikawajima's only engine assembly plant for new engines (appendix A).

In September 1941, The Ishikawajima Aircraft Co. was reorganized to constitute an independent corporation with stock ownership vested in the Ishikawajima Shipbuilding Co. Capitalization increased thereafter and eventually reached a 92,000,000 yen total.

With the impetus of government demand, expansion of the Tomioka plant was almost continuous and new plants were purchased and built. Excluding dispersal units (covered later in this report), at the time of the Japanese surrender Ishikawajima consisted of four fabrication and assembly plants, one of which was not yet in operation, and three accessory plants. These were as follows:

Fabrication and assembly plants:

- Tomioka plant, in Isogo Ward, Tomioka, a suburb of Yokohama.
- Chuetsu plant, at DeMachi, Higashi Tonami County, Toyama Prefecture.
- Hidaka plant, in Wakayama Prefecture.
- Yamato plant, in Yamato Precinct, Koza County, Kanagawa Prefecture.

Accessory plants:

- Nakamura-Bashi plant, in Minami Ward, Nakamura Precinct, in Yokohama.
- Adachi plant, in Adachi Ward, Kono Precinct of Tokyo.
- Amakami plant, in Kami Precinct, Nishi Negishi, Yokohama.

In addition to these seven works, the Ishikawajima Co. owned several warehouses, used for the storage of parts and tools, in the Yokohama area.

The Japanese Government at no time directly controlled, operated, subsidized, or owned any part of the Ishikawajima Co. Governmental relationship was indirect only, in that it (*a*) loaned the company about 30 percent of its plant machinery, (*b*) loaned the company money from government banks, (*c*) established price controls and, of course, (*d*) granted material priorities and allocations, (*e*) furnished labor, and (*f*) inspected finished products. A staff of nine naval officers comprised the company's inspection staff: this staff was headed by Captain (Navy) Masukichi Kondo in 1945.

ORGANIZATION AND OPERATION

Key executives of the corporation are listed below:

President	Hikosuke Araki.
Chief director	Kensuke Nagano.
Managing directors	Kiyoshi Matsukasa, Kazue Sano, Koichi Kanda.
Directors	Itsugi Kasehara, Ichiji Otsuka, Tsuneo Nonaka.
Auditor	Masanori Nakayama.
Business manager	Kazue Sano.
Personnel chief	Tsuneo Nonaka.
Planning chief	Kiyoshi Matsukasa.

The organizational structure of the Ishikawajima Co. was built around the Tomioka plant as the major fabrication and assembly unit. The Chuetsu, Hidaka, and Yamato plants were intended to supply parts and assemblies to Tomioka for final assembly of HA–35 engines (appendix A). Hidaka was, in addition, to produce turbo-superchargers for the Navy. The three small accessory plants—Nakamura-Bashi, Adachi, and Amakami—complemented the organization of the company (appendix B).

The Tomioka plant was the original and largest unit of the company, and the only works at which new engines were assembled. It also repaired damaged engines and fabricated various engine parts for other manufacturers as well as for its own assembly operations. No assembly line technique was used; job shop practices, only, were employed.

The Chuetsu plant, a fabrication and assembly factory, repaired damaged engines, fabricated parts for the Tomioka plant, and heat-treated castings for the Navy. It was acquired in November 1943 and operated continuously thereafter until August 1945.

The Hidaka and Yamato plants were intended to be the remaining two major fabrication and assembly units. The Hidaka plant was converted from a factory of the Chuetsu Textile Co. in September 1943 and began small-scale operations in December of that year. It originally had been intended only for the fabrication of exhaust turbo-superchargers for the Navy, but several changes of plans and orders by the Navy prevented this being put into effect. Hidaka's role, consequently, was limited to production of parts for the Tomioka plant (appendix C). The Yamato plant was started in May 1943, but construction was not completed before the surrender to the Allies.

The Nakamura-Bashi, Adachi, and Amakami plants were small accessory producers, supplying parts or services for the Tomioka plant. Nakamura-Bashi began operations in August 1943 as a heat-treatment unit. Adachi, organized in March 1944, was a metal-rolling mill. Amakami, acquired in October 1944, was the company's lumber mill.

Principal suppliers of raw materials and component parts, numbering approximately 70, of the Ishikawajima complex were almost all located in the Tokyo-Kawasaki area adjacent to the plant and only a few were as far away as Kobe or Nagoya (reference item 1).

Employment increased steadily and gradually, both in numbers and man-hours worked, until November 1944. In December 1944 the number of employees declined gradually, and beginning in December 1944 man-hours worked began a long decline which became precipitous after the dispersal program was started in April (appendices D–1, D–2, E–1, and E–2).

Percent of man-hours of work lost, for all reasons, was high and erratic, varying from a low of 14.6 to a high of 48.4 percent (appendixes E–1 and E–2). In the last 4 years prior to the surrender, 11,843,860 man-hours, or 27.5 percent of the total, were lost. Since there were no direct air attacks on any works, that factor did not affect man-hours lost. Indirect air attacks had little effect on lost time increasing the total loss from 1 to only 3 percent except during the final month of August 1945, when this factor caused a 14.8-percent loss. Table 1, below, indicates the yearly trend of lost time.

TABLE 1.—*Employee and man-hour trends*

	Total employees	Man-hours worked	Man-hours lost	Percent man-hours lost
July 1942	2, 820	533, 593	185, 930	34. 8
July 1943	3, 562	753, 320	267, 360	35. 5
July 1944	5, 965	1, 284, 274	355, 000	27. 6
July 1945	5, 608	1, 076, 323	358, 000	33. 7

Of the total employees, about 7 precent were women and this percentage did not fluctuate materially. No records of this trend were available after March 1944. Student labor was supplied by the government beginning in April 1944 and this category increased steadily, reaching a total of 2,001 by August 1945. Soldier labor also was used, beginning in July 1944, but this category averaged only about 3 percent of the total employees (appendices D–1 and D–2).

The ration of nonproductive labor was fairly constant, declining from a high of 50.2 percent in December 1941 to a low of 29.7 percent in October 1944, and averaged about 35 to 37 percent, a value quite comparable with the average American works of this approximate size (appendices D–1 and D–2).

Multiple, round-the-clock shifts were inaugurated in October 1943, immediately after the Hidaka plant was placed in operation, and prior to acquisition of the Chuetsu plant. Thus, the percentage of night-shift workers had relatively little effect on plant efficiency. This percentage increased rapidly to a high plateau of an average of from 16 to 18 percent from February through November 1944, and declined rapidly thereafter (appendices D–1 and D–2).

Labor turnover (new employees to total employment) trends were erratic and abrupt, from a low of 0.2 percent to a high of 26.7 percent. During the last 14 months of the war, however, labor turnover steadied at a relatively even low level, in spite of the fact that the number of employees discharged remained erratic and relatively high (appendices F–1 and F–2). The term "discharged employees" includes all persons released for various reasons.

THE DISPERSAL PROGRAM

Prior to the directive of the Central Section for Planning Defense of Production (Rinji Seisan Bōei Taisaku Chūō Honu) of the Munitions Ministry of 4 April 1945 which ordered all aircraft manufacturers to disperse their activities, the Ishikawajima Co. had asked the Government to be allowed to disperse some units and on their own initiative, planned and carried out one dispersal movement, namely; some machine shop processes transferred from the Tomioka plant to an underground site at the Chuetsu plant. After the 4 April order, dispersal was undertaken with maximum effort.

At the time of the dispersal order, construction of the Yamato plant was incomplete and the Chuetsu plant had not begun to produce turbosuperchargers. These works, therefore, together with the three small accessory plants (Adachi, Amakami, and Nakamura-Bashi) were not dispersed; the Tomioka and Hidaka plants were.

Ishikawajima's dispersal was carried out in two stages. The first, as a result of the 4 April order, involved the moving of activities from the Tomioka plant to underground machine shops at the following locations: Chuetsu, Sugita, Negishi, Sōbu, Yokosuka Naval Arsenal, Sanuki.

The second dispersal, as a result of the Munitions Ministry order of 22 May 1945, for protection of production facilities in the Kinki area, involved moving machine shops from the Hidaka plant to the Tomioka plant and to the Chuetsu and Sanuki underground locations.

Plans also had been drawn to disperse the heat treatment and assembly processes to underground plants at Nakamura, near Negishi, but these plans never materialized. Of the company's total 1,318 machine tools, it was planned to disperse all; actually, only 887, or 68 percent were dispersed (appendix G). Korean labor was used extensively in dispersal operations.

The above-mentioned underground shops, except at the Yokosuka Naval Arsenal and Sanuki, were all relatively small cave-type, mountainside tunnels located in the vicinity of the Tomioka plant. The Yokosuka Naval Arsenal was located about 3 miles south of the Tomioka plant. The Sanuki underground location, near Chiba, was accessible only by water across Tokyo Bay.

THE AIR ATTACKS

AIR ATTACKS ON URBAN AREAS

The Ishikawajima Co. was neither selected nor attacked as a primary target. Units of the company, however, were struck three times in attacks on adjacent urban areas (appendix H). Data of these attacks were ascertained from records of the Tabulating Service Section of the United States Strategic Bombing Survey.

The attacks upon company installations, except in the case of the Tomioka plant, did not affect production (appendix H). Damage of Tomioka's gas supply system in the 29 June attack caused a suspension of heat treating operations and resulted in a production loss of about 90 engines in July. Effects on other installations was limited to incendiary damage and destruction of warehouses, tools, and material stocks. No fatalities were sustained.

Generally, attacks of the Yokohama-Tokyo area became so effective beginning in March and April 1945 that the Ishikawajima Co. found it impossible to carry out planned operations and engine production was reduced about 25 percent in those months. The 29 May attack destroyed the homes of 2,500 workers and caused a loss of 30,000 man-hours of work.

Morale had been generally good until 12 June, when a nearby plant was struck by HE; Ishikawajima workers saw casualties at first hand, heard many stories and became nervous and "jumpy" as a result. The increased bombings of July made them feel they were continuously moving closer to their own turn, and nervousness and inefficiency increased. As a rule, HE was dreaded more than IB attacks.

Day and night attacks in June and July slowed down dispersal activities because of disruptions to transportation and workers' homes, and production declined rapidly to about 50 percent of its March value. Practically all suppliers of raw materials and component parts were located in the Yokohama-Tokyo urban area and continued attacks in this area served to reduce and deny receipts from these suppliers. New supply sources could not be found.

PRODUCTION STATISTICS

Ishikawajima's capacity for production of engines rose steadily from 25 in September 1942 to a level of 210 in November 1944 and remained constant thereafter (appendices I–1 and I–2). This steady increase was based partially on anticipated receipts of machine tools promised by the Government. The acquisition and operation of the Hidaka and Chuetsu fabrication and assembly plants in September and November 1943 and the four accessory plants between May 1943 and October 1944 did not in any case sharply increase engine production capacity since none of these plants were final assembly works: the Hidaka plant, as a matter of fact, had been intended solely for the production of exhaust-driven turbo-superchargers for the Navy.

Government demand, or orders, was entirely inconsistent with Ishikawajima's ability to produce engines. Orders initially were given for 6 month periods: in April 1944 this was reduced to a 4-month short-term form of order. These demands increased in relatively small amounts until Ishikawajima's ability to produce exceeded Government demand in the first quarter of 1944: thereafter, demands skyrocketed out of all proportion to the company's ability to produce and reached a high demand of 420 engines per month in February and March 1945. Thereafter, demand declined abruptly to below theoretical ability to produce (appendixes I–1 and I–2).

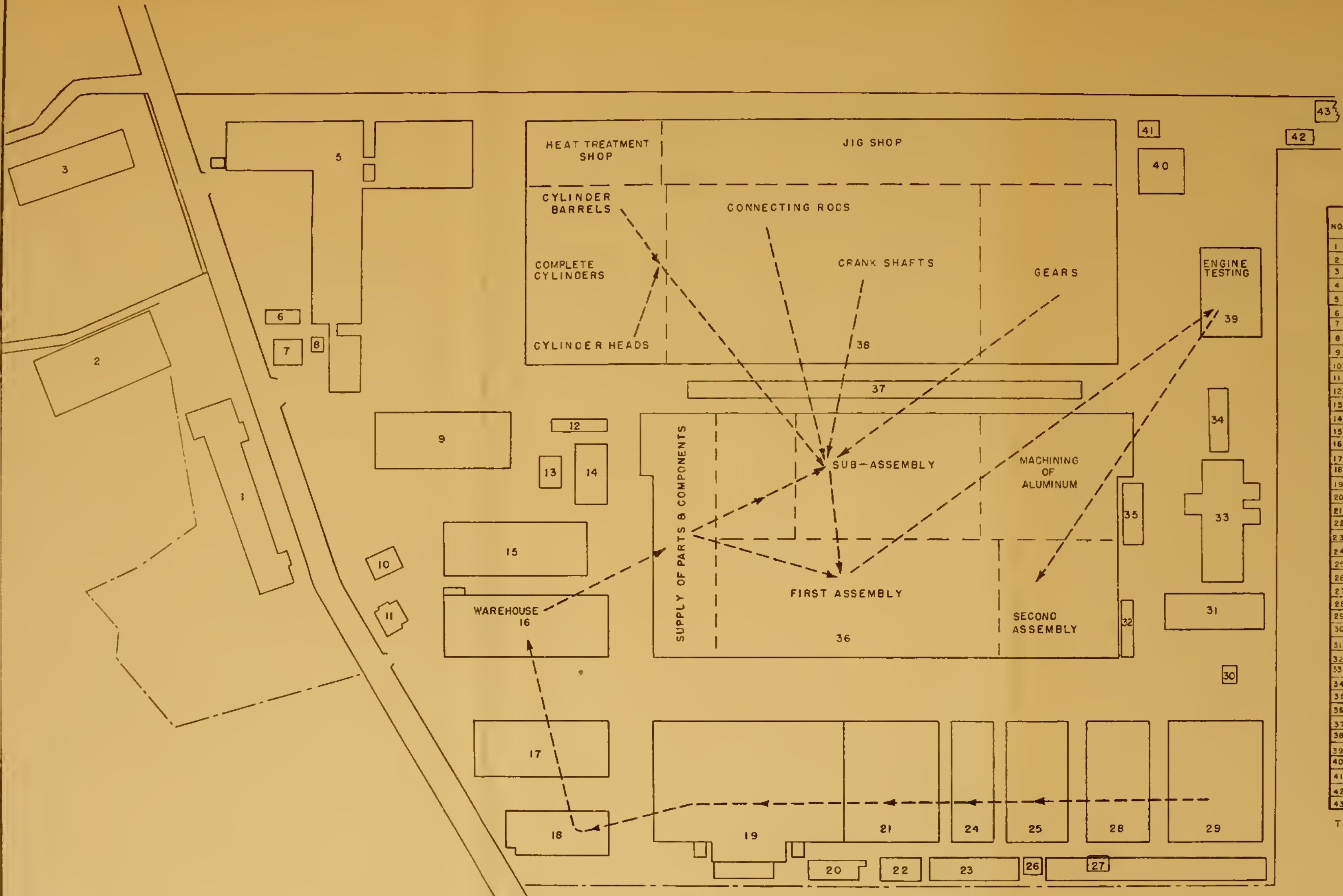
Contrasting both plant capacity and Government demand, actual production at no time reached either ordered or capacity level. Initially, Ishikawajima had insufficient technically trained and experienced workers to carry out a mass production plan. The first Government orders failed to take this into account. Thereafter the Government failed to provide promised machine tools (especially internal grinders) in time and this resulted in production schedules being set back about 6 months in 1943.

In 1944, shortage of labor was the most serious problem: many experienced production men and young engineers were drafted into the services. As a result of this industry-wide shortage the Government instituted a program of drafting students and soldiers into factory labor jobs in April. Ishikawajima thus suddenly received a large number of untrained laborers. As a result, fabrication rejections because of poor workmanship increased to almost 30 percent.

Beginning late in 1944, nickel-steel became critically short in supply and substitute materials were used. This resulted in many complications. The use of softer, lower grade steel in such engine parts as reduction gears, which require a high degree of hardness, caused repeated engine failures in test and acceptance.

This condition was a material factor in the production decline late in 1944 and early in 1945. Also, in the beginning of 1945, receipts of parts such as rocker arms, inlet valves, and push rods, from the Chuetsu plant in Toyama Prefecture, dropped materially. This was caused by rail disruptions resulting both from effects of American bombings and heavy snowfalls during that winter.

Analysis of production curves shows that output increased steadily from the first engine assembled in December 1941 until the peak of 150 was attained in June 1944 (appendixes I–1 and I–2). Production declined sharply in July and August because of difficulties in obtaining raw materials and because of the loss of experienced and key men to the military services, mentioned above. Recovery was further retarded during the winter of 1944–45 by dispersal of some machining opera-



NO.	FLOOR AREA SQ. FT.	NO. FLOOR	TYPE	DATE BUILT	USE
1	10980	2	WOOD	9-39	APPRENTICE SCHOOL
2	11130	2	WOOD	10-43	APPRENTICE SCHOOL
3	5490	2	WOOD	10-43	HOSPITAL
4	162	1	WOOD		GUARD HOUSE
5	28450	2	WOOD	8-43	OFFICES
6	710	1	WOOD		GARAGE
7	710	1	WOOD		GUARD HOUSE
8	180	1	WOOD		STORAGE
9	16610	2	WOOD	7-44	MESS HALL
10	710	1	WOOD		OFFICE
11	710	1	WOOD	12-38	GUARD HOUSE
12	864	-	CONCRETE		WATER TANK
13	2695	2	WOOD	7-43	OFFICE
14	3225	2	WOOD	9-39	TRANSFORMER STATION
15	8175	2	WOOD	7-40	POWER STATION
16	17940	2	CONCRETE	10-39	SUPPLY WAREHOUSE
17	12800	2	WOOD	10-40	PATTERN FOUNDRY
18	3675	1	WOOD	10-41	FINISHING FOUNDRY
19	36900	2	IRON FRAME	8-38	CASTING FOUNDRY
20	936	1	WOOD	12-38	WASH ROOM
21	9680	1	IRON FRAME	9-39	HEAT TREATMENT
22	939	1	WOOD	12-38	BATH HOUSE
23	1672	1	WOOD	12-38	SAND BLAST COMPRESSORS
24	4300	1	WOOD	12-38	PLATE SHOP
25	6175	1	WOOD	5-38	PLATING SHOP
26	226	1	CONCRETE	1-41	ACETYLENE GAS WORKS
27	4660	1	WOOD	6-42	PUMPHOUSE SCRAP STORAGE
28	6340	1	WOOD	5-38	SCRAP
29	9680	1	IRON FRAME	3-41	CASTING & FORGING
30	244	1	WOOD		OIL HOUSE
31	3226	1	WOOD		BUFFING SHOP
32	415		CONCRETE		WATER TANK
33	5290	2	WOOD	7-40	SUPPLY WAREHOUSE
34	1122	1	CONCRETE		ENGINE TEST CELLS
35	1055	1			PARTS WASHING
36	98550	1	IRON FRAME	3-39	MACHINE & ASSEMBLY SHOP
37	6348	1	WOOD		SHOP OFFICES
38	125900	1	IRON FRAME	8-41	MACHINE SHOP
39	7920	2	CONCRETE	2-40	ENGINE TEST SHOP
40	1914	-	CONCRETE	1-41	UNDERGROUND OIL TANKS
41	226	1	WOOD	1-41	PUMP HOUSE
42	226	1	WOOD	9-38	OIL SHED
43	6200	2	WOOD	3-45	ENGINE TEST CELL

TOTAL FLOOR AREA' 465,170 SQ FT

PLANT LAYOUT & PRODUCTION FLOW

TOMIOKA PLANT

1945

US STRATEGIC BOMBING SURVEY

ISHIKAWAJIMA AIRCRAFT
INDUSTRIES COMPANY

APPENDIX — A

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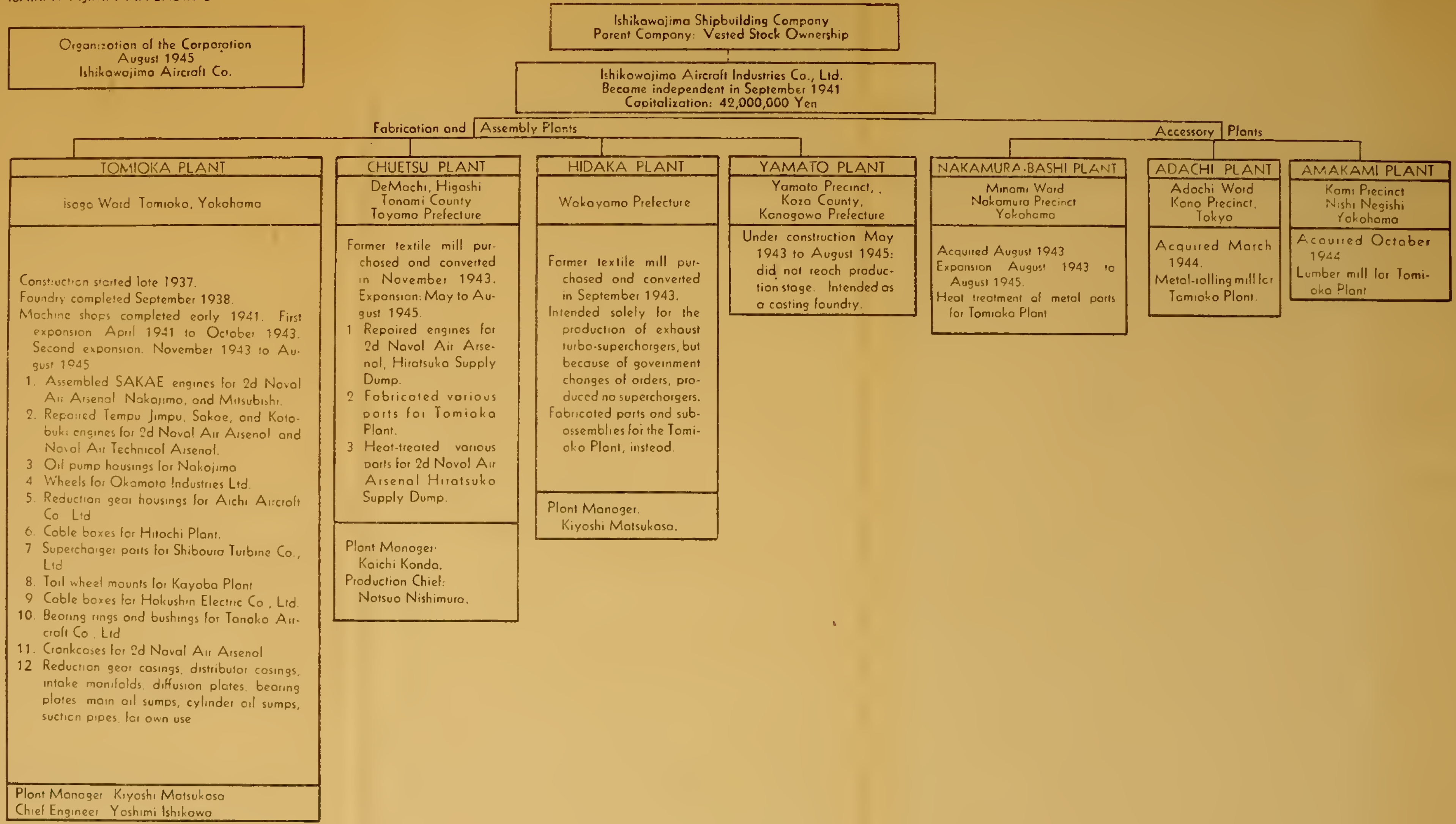
ISHIKAWAJIMA APPENDIX B

Organization of the Corporation
August 1945
Ishikawajima Aircraft Co.



Ishikawajima Shipbuilding Company
Parent Company: Vested Stock Ownership

Ishikawajima Aircraft Industries Co., Ltd.
Become independent in September 1941
Capitalization: 42,000,000 Yen

Fabrication and Assembly Plants

TOMIOKA PLANT

Isogo Ward Tomioka, Yokohama

Construction started late 1937.
Foundry completed September 1938.
Machine shops completed early 1941. First expansion April 1941 to October 1943. Second expansion. November 1943 to August 1945

1. Assembled SAKAE engines for 2d Naval Air Arsenal Nakajima, and Mitsubishi.
2. Repaired Tempu Jimpu, Sakae, and Kotobuki engines for 2d Naval Air Arsenal and Naval Air Technical Arsenal.
3 Oil pump housings for Nakajima
4 Wheels for Okamoto Industries Ltd.
5. Reduction gear housings for Aichi Aircraft Co Ltd
6. Cable boxes for Hitachi Plant.
7 Supercharger parts for Shibaura Turbine Co., Ltd
8. Tail wheel mounts for Kayaba Plant
9 Cable boxes for Hokushin Electric Co , Ltd.
10. Bearing rings and bushings for Tanaka Aircraft Co . Ltd
11. Crankcases for 2d Naval Air Arsenal
12 Reduction gear casings, distributor casings, intake manifolds, diffusion plates, bearing plates main oil sumps, cylinder oil sumps, suction pipes, for own use

Plant Manager Kiyoshi Matsukasa
Chief Engineer Yoshimi Ishikawa

CHUETSU PLANT

DeMachi, Higashi
Tonami County
Toyama Prefecture

Former textile mill purchased and converted in November 1943. Expansion: May to August 1945.

1 Repaired engines for 2d Naval Air Arsenal, Hiratsuka Supply Dump.
2 Fabricated various parts for Tomiaka Plant.
3 Heat-treated various parts for 2d Naval Air Arsenal Hiratsuka Supply Dump.

Plant Manager:
Koichi Kondo.
Production Chief:
Natsuo Nishimura.

HIDAKA PLANT

Wakayama Prefecture

Former textile mill purchased and converted in September 1943.
Intended solely for the production of exhaust turbo-superchargers, but because of government changes of orders, produced no superchargers.
Fabricated parts and subassemblies for the Tomioka Plant, instead.

Plant Manager.
Kiyoshi Matsukasa.

YAMATO PLANT

Yamato Precinct,
Koza County,
Kanagawa Prefecture

Under construction May 1943 to August 1945: did not reach production stage. Intended as a casting foundry.

Accessory Plants

NAKAMURA-BASHI PLANT

Minami Ward
Nakamura Precinct
Yokohama

Acquired August 1943
Expansion August 1943 to August 1945.
Heat treatment of metal parts for Tomiaka Plant

ADACHI PLANT

Adachi Ward
Kano Precinct,
Tokyo

Acquired March 1944.
Metal-rolling mill for Tomioka Plant.

AMAKAMI PLANT

Kami Precinct
Nishi Negishi
Yokohama

Acquired October 1944
Lumber mill for Tomioka Plant

tions to the distant Chuetsu underground plant, but again reached the 150 per month peak in March 1945.

During April, May, and June, increasing air attacks continued to disrupt transportation and lower morale to such an extent that production declined about 25 percent. Thereafter, the company's attempts at large-scale dispersal brought the parts producing units to a virtual halt, and engine production declined sharply to 67 percent in July and zero in August.

The Tomioka and Chuetsu plants, in addition to their fabrication activities, also repaired Sakae, Jimpu, Tempu, and Kotobuki engines (table 2).

TABLE 2.—*Engine repairs completed*

	Sakae	Tempu	Jimpu	Kotobuki	Total
1940				20	20
1941				60	60
1942	73	1	2		76
1943	36				36
1944	18				18
1945	36				36
Totals	163	1	2	80	246

The 2d Naval Air Depot at Kizarazu, in Chiba, was the center for engine repair. Only defective engines or break-down cases were sent to Ishikawajima for repair: no battle- or accident-damaged engines were received.

New engines were given only a 1-hour test run, and it was found that breakdowns developed after about 30 hours of running. These failures were usually due to cylinder-wall wear, near the top of stroke, and was attributed to the use of substitute, softer metals. This type of failure also caused rapid plug fouling from leakage around the piston. At one time about 50 percent of engines were not passing inspection, and about 80 percent were repair cases of worn cylinder walls and 20 percent worn reduction gear bearings.

Prior to the spring of 1945 about 10 percent of Ishikawajima's engine assembly activities were devoted to that type of repair. After that time, although shortages of needed parts for assembly of new engines made more men available for engine repair work, repairable engines were stripped for salvage parts used in new engine assembly.

EVALUATION OF PRE-ATTACK INTELLIGENCE

Intelligence data of Ishikawajima's operations were meager, albeit essentially correct. It included only air photos of the Tomioka plant area, with suspected underground shop locations. These were correct and identifications of uses of plant buildings were correct for the major units.

Intelligence information for Ishikawajima engine plant, Tomioka, Yokohama, was as follows: "Estimated 500 units per year or 2 percent of Jap aircraft engine production. Also, parts, foundry, subcontracting for other major plants in area. Modern factory with many imported machine tools installed in 1939. Reported underground shops. May still produce some airframes at this plant or at the dockyard."

Actually, Ishikawajima's production in 1943 was only 390 engines, or 0.7 percent of Japan's total. Also, no airframes had ever been built by this company. This intelligence information is, of course, that of 1943: no addenda was found to indicate knowledge of the scope of Ishikawajima's expansion and dispersals since that year.

REFERENCE NOTES

Reference material for this report is filed with the records of the United States Strategic Bombing Survey, War Department, Washington, D. C., care of the Adjutant General. (Reference Item 1—Suppliers of Raw Materials and Component Parts.)

HISTORY OF THE HIDAKA PLANT

The Hidaka plant of the Ishikawajima Aircraft Industries Co., Ltd., located in Hidaka Gun, Wakayama Ken, on the north coast of Honshu, was, prior to its purchase in September 1943, a branch factory of the Chuetsu Textile Co., Ltd., whose main offices and plant were located in DeMachi, in Higashi Tonami County in Toyama Prefecture.

After this purchase, the Ishikawajima Co., which had been carrying out its experiemental projects on aircraft engines and turbo-superchargers in its Tomioka plant, transferred these activities to the Hidaka plant. This transfer begun in December 1943, involved 50 machine tools and 100 employees, and was carried out in small increments lasting 1 year. At that time, experimental work had progressed to the stage where the company was prepared to start work on production of 50 I ET model 5 2,000 H exhaust-driven turbo-superchargers for the Navy as an experimental order.

The production problem initially was primarily the acquisition of machine tools to equip this factory for production. Some all-purpose machine tools were on hand, but production schedules demanded various special-type tools such as special grinders to finish turbine blades. However, since other companies were being expanded at the time, these tools could not be obtained rapidly.

In the meantime, military demands for turbo-superchargers became pressing. In March 1944 the Munitions Ministry ordered production of Mitsubishi Model 2 1,000 H exhaust-driven turbo-superchargers, a type considered more generally adapted to combat. Accordingly, Ishikawajima set up plans for producing 450 of these units per month using 250 machine tools and 2,060 employees by March 1945, and because of shortage of machine tools, adopted the three-shift system of work. Production was to have begun in June 1944.

Acquisition of materials proceeded fairly smoothly but it still was found to be impossible to obtain the required machine tools. Only in the installation of the heat treatment shop was good progress made, and this shop was completed by 6 June. Plant operations during that time were devoted to making tools for large-scale production of both the Mitsubishi Model 2 and the I ET Model 5 turbo-superchargers, and the training of newly-hired inexperienced workers. However, most of these new employees were also used in conversion of plant structures and reclamation of adjacent land purchased for expansion of the plant.

Work progressed slowly through June, and in July, as sheet-metal parts and forgings were being received, the Munitions Ministry suddenly ordered production of turbo-superchargers halted and experimental work begun on a turbine rocket motor known as TR. Current production plans accordingly were dropped, and this resulted in a surplus of employees and trainees. To absorb this excess, the Hidaka plant in August took over some subcontract fabrication of fuselage parts of the fighter George for the Naruo plant of the Kawanishi Aircraft Industries Co., Ltd., and fabrication of JZKI bulletproof cockpit-frame windshields for the Navy.

In order to obtain needed machine tools for the production of the TR turbine rocket motors, the Shibayama Steel Works in Wakayama was purchased in September 1944. This Shibayama Works had been engaged in production of slotting machines, and this acquisition added about 100 machine tools, a large amount of stock parts, and about 50 employees to the Hidaka plant rolls. These machine tools, however, were so old that a considerable period of time was required for reconverting them for TR production.

In October, a labor capacity surplus still remaining, it was decided to use some labor to fabricate small parts for production of the Sakae 20-series engines being made at the Tomioka plant. It was intended to produce 16 different types of small parts, the largest being the articulated connecting rod. Production was to have been started in January 1945.

From October through December, some machine tools from the Shibayama Works and a few new tools of the Munition Ministry's allocation were obtained. The Shibayama tools, however, were unfit for use without extensive reconversion work expended on them.

At the end of December, when experimental work on the TR turbine rocket motor was nearing completion, the Munition Ministry again suddenly ordered all work on this project stopped. The Ishikawajima Co. then decided to concentrate all its Hidaka plant facilities on manufacturing parts for its own Tomioka plant and accordingly gave up its subcontract sheet-metal work for Kawanishi and bulletproof windshields for the Navy.

Parts production, which had been scheduled to begin in January 1945 was delayed by typical Japanese bungling and finally was begun in March. Using the machine tools which had been intended for the production of the TR turbine rocket motors Hidaka produced master connecting rods, propellor shafts, reduction gear housings, pinion cages, and other large parts, in addition to the smaller parts originally planned.

After April, that part of the Tomioka plant which had fabricated master connecting rods, articulated connecting rods, and wristpins, was moved to Hidaka. At the same time, since the Tomioka plant was suffering from a labor shortage, and also to reduce the number of trainees at the Hidaka plant, Hidaka shipped almost all of its student laborers and a small number of its experienced workers, about 350 people in all, to Tomioka. In June, after the above mentioned part of the Tomioka plant moved to Hidaka was placed in operation, these 350 workers were recalled.

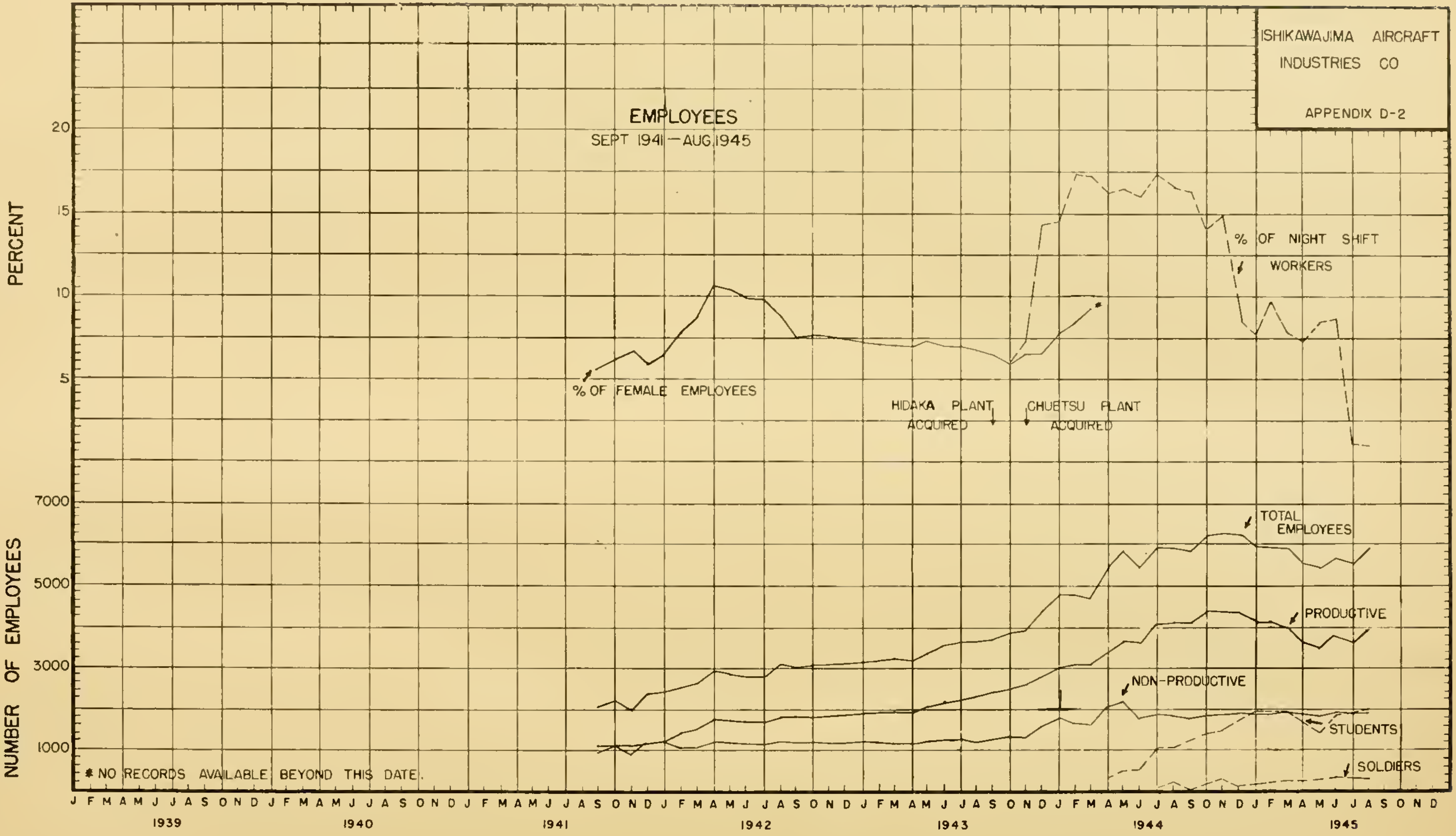
In April the Munitions Ministry's dispersal directive forced Hidaka to abandon completely all current expansion plans. On 22 May the formal dispersal order was received and the Hidaka plant was completely dispersed to the Chuetsu, Tomioka, and Sanuki locations. During this period of dispersal, air attack alerts and attacks on nearby installations delayed movement activities to the extent that dispersion to Chuetsu and Tomioka was not completed before the end of the war.

ISHIKAWAJIMA APPENDIX D-1

Employment data

	Male	Female	Percent	Students	Soldiers	Total	Productive	Nonproductive	Percent	Percent night shift
1941										
September	1,936	108	5.6	--------	--------	2,044	1,077	967	47.3	----
October	1,991	120	6.3	--------	--------	2,111	1,110	1,001	147.4	---
November	1,882	128	6.8	--------	--------	2,010	1,071	939	46.7	--------
December	2,188	133	6.1	--------	--------	2,321	1,154	1,167	50.2	--------
1942										
January	2,211	155	7.0	--------	--------	2,366	1,185	1,181	49.9	--------
February	2,236	181	8.1	--------	--------	2,417	1,367	1,050	43.4	--------
March	2,265	199	8.8	--------	--------	2,464	1,414	1,050	42.6	--------
April	2,614	289	11.1	--------	--------	2,903	1,710	1,193	41.1	--------
May	2,577	271	10.5	--------	--------	2,848	1,695	1,153	40.5	--------
June	2,576	250	9.7	--------	--------	2,826	1,690	1,136	40.2	--------
July	2,574	246	9.6	--------	--------	2,820	1,690	1,130	40.1	--------
August	2.833	247	8.7	--------	--------	3,080	1,825	1,255	40.7	--------
September	2,794	213	7.4	--------	--------	3,007	1,815	1,192	39.6	--------
October	2,817	214	7.6	--------	--------	3,031	1,820	1,211	40.0	--------
November	2,821	212	7.5	--------	--------	3,033	1,825	1,208	39.8	--------
December	2,829	210	7.4	--------	--------	3,039	1,859	1,180	38.8	--------
1943										
January	2,865	210	7.3	--------	--------	3,075	1,865	1,210	39.3	--------
February	2,888	202	7.0	--------	--------	3,090	1,895	1,195	38.7	--------
March	2,911	203	7.0	--------	--------	3,114	1,962	1,152	37.0	--------
April	2,886	195	6.8	--------	--------	3,081	1,940	1,141	37.0	--------
May	3,098	225	7.3	--------	--------	3,323	2,110	1,213	36.5	--------
June	3,257	219	6.7	--------	--------	3,476	2,259	1,217	35.0	--------
July	3,341	221	6.6	--------	--------	3,562	2,330	1,232	34.6	--------
August	3,334	215	6.4	--------	--------	3,549	2,380	1,169	32.9	--------
September	3,448	202	5.9	--------	--------	3,650	2,480	1,170	32.1	--------
October	3,700	208	5.6	--------	--------	3,908	2,548	1,360	34.8	5.53
November	3,722	243	6.5	--------	--------	3,965	2,625	1,340	33 8	9.68
December	4,157	270	6.5	--------	--------	4,427	2,805	1,622	36.6	13.59
1944										
January	4,478	354	7.9	--------	--------	4,832	3,019	1,813	37.5	14.43
February	4,442	377	8.5	--------	--------	4,819	3,161	1,658	34.4	17.84
March	4,353	401	9.2	--------	--------	4,754	3,146	1,608	33.8	17.64
April	--------	--------	--------	300	--------	5,464	3,406	2,058	37.7	16.28
May	--------	--------	--------	448	--------	5,888	3,664	2,224	37.8	16.62
June	--------	--------	--------	458	--------	5,427	3,624	1,803	33.2	16.08
July	--------	--------	--------	1,021	39	5,965	4,068	1,897	31.8	17.81
August	--------	--------	--------	1,021	191	5,950	4,097	1,853	31.1	16.97
September	--------	--------	--------	1,213	20	5,897	4,094	1,803	30.6	16.7
October	--------	--------	--------	1,431	179	6,213	4,365	1,848	29.7	13.58
November	--------	--------	--------	1,475	242	6,242	4,377	1,865	29.9	14.71
December	--------	--------	--------	1,707	118	6,188	4,302	1,886	30.5	8.44
1945										
January	--------	--------	--------	1,941	123	5,944	4,072	1,872	31.5	7.31
February	--------	--------	--------	1,941	199	5,984	4,106	1.878	31.3	9.15
March	--------	--------	--------	1,941	224	5,917	4,003	1,914	32.3	7.4
April	--------	--------	--------	1,659	215	5,607	3,724	1,883	33.4	7.02
May	--------	--------	--------	1,457	239	5,456	3,593	1,863	34.1	8.31
June	--------	--------	--------	1,792	275	5,763	3,849	1,914	33.2	8.42
July	--------	--------	--------	1,883	271	5,608	3,725	1,883	33.6	1.3
August	--------	--------	--------	2,001	270	5,935	3,976	1,959	33.0	1.03

ISHIKAWAJIMA APPENDIX D-2

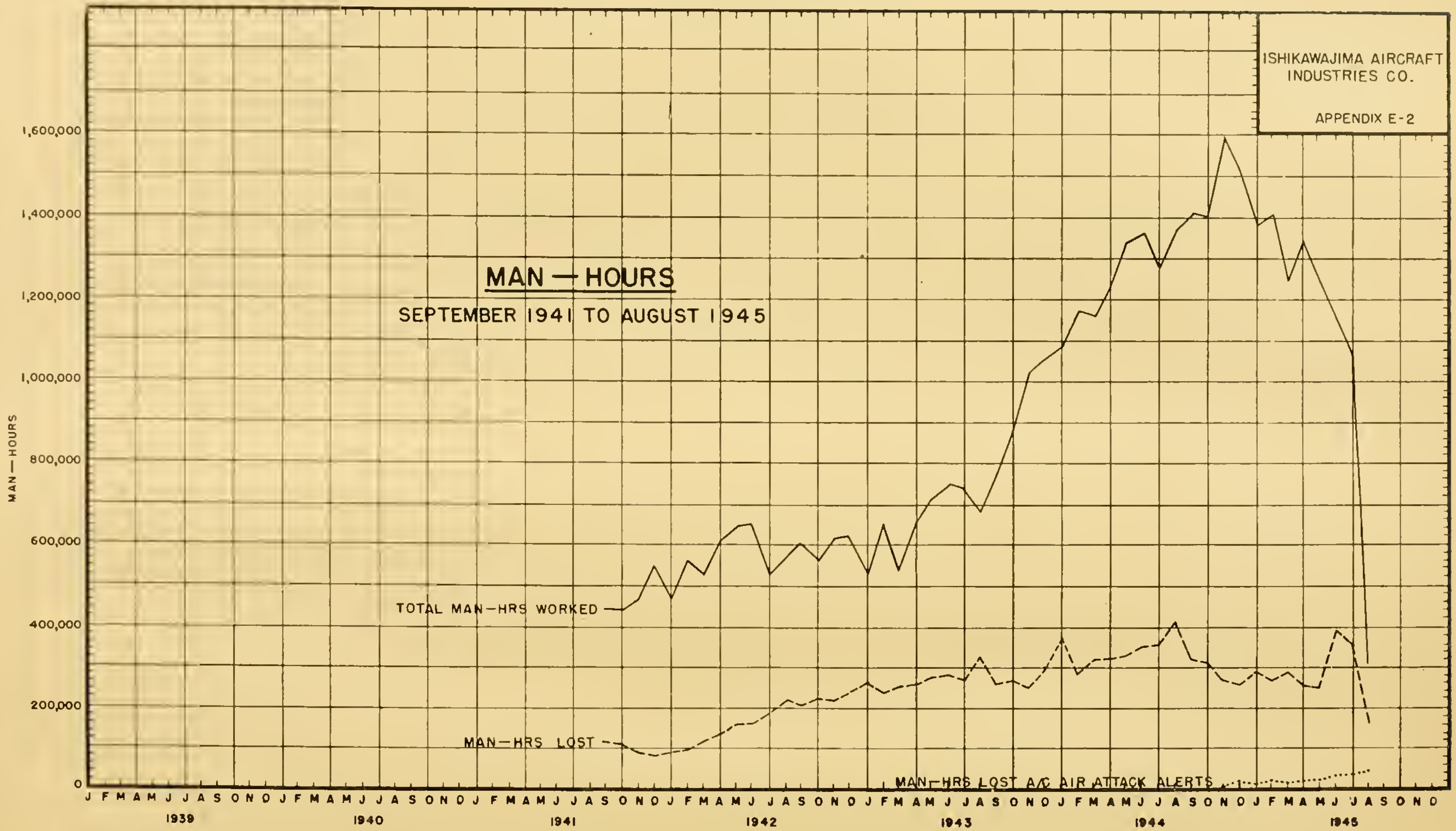


ISHIKAWAJIMA APPENDIX E-1

Man-hours

	Percent of required	Man-hours worked	Total man-hours lost	Percent	Man-hours lost a/c attack alerts	Percent	Man-hours (planned) required
1941							
September		446,336	114,280	25.6			
October		441,129	111,010	25.1			
November		470,931	88,260	18.7			
December		555,504	80,850	14.6			
1942							
January		475,224	87,010	18.3			
February		566,711	96,660	17.1			
March		535,316	116,010	21.7			
April		612,134	133,140	21.8			
May		642,183	158,310	24.7			
June		649,917	161,810	24.9			
July		533,593	185,930	34.8			
August		583,305	225,670	38.7			
September		602,061	207,460	34.5			
October		569,422	223,170	39.2			
November		622,348	202,910	32.6			
December		630,658	234,340	37.2			
1943							
January	14.9	540,695	261,560	48.4			3,610,000
February	18.3	661,320	237,580	35.9			3,610,000
March	15.4	554,406	248,950	41.9			3,610,000
April	26.9	667,105	257,190	38.6			2,480,000
May	29.0	720,256	273,260	37.9			2,480,000
June	30.5	757,217	278,160	36.7			2,480,000
July	45.4	753,320	267,360	35.5			1,660,000
August	39.4	685,974	327,940	47.8			1,740,000
September	45.0	783,124	258,230	33.0			1,740,000
October	42.6	882,179	266,750	30.2			2,070,000
November	49.5	1,025,456	253,180	24.7			2,070,000
December	48.8	1,059,967	299,350	28.2			2,170,000
1944							
January	71.1	1,087,230	370,000	34.0			1,530,000
February	76.9	1,176,437	280,710	23.9			1,530,000
March	76.0	1,162,859	316,720	27.2			1,530,000
April	57.7	1,228,606	321,760	26.2			2,130,000
May	62.8	1,337,916	327,000	24.4			2,130,000
June	40.6	1,364,592	350,000	25.6			3,360,000
July	41.8	1,284,274	355,000	27.6			3,070,000
August	44.6	1,370,738	415,810	30.3			3,070,000
September	45.9	1,408,024	324,000	23.0			3,070,000
October	33.2	1,403,899	316,000	22.5			4,230,000
November	37.9	1,601,120	273,000	17.1	693	0.04	4,230,000
December	35.8	1,516,184	259,980	17.1	20,537	1.4	4,230,000
1945							
January	33.9	1,383,071	289,000	20.9	10,367	.8	4,080,000
February	34.5	1,408,401	264,000	18.7	20,816	1.5	4,080,000
March	30.6	1,247,038	290,000	23.3	16,583	1.3	4,080,000
April	63.3	1,347,874	359,000	19.2	19,600	1.5	2,130,000
May	58.5	1,247,073	250,000	20.0	22,503	1.8	2,130,000
June	54.3	1,156,588	387,390	33.5	33,646	2.9	2,130,000
July	50.5	1,076,323	358,000	33.3	37,130	3.4	2,130,000
August	14.7	312,746	180,160	34.6	46,280	14.8	2,130,000
Total		43,149,084	11,843,360	27.5			

ISHIKAWAJIMA APPENDIX E-2

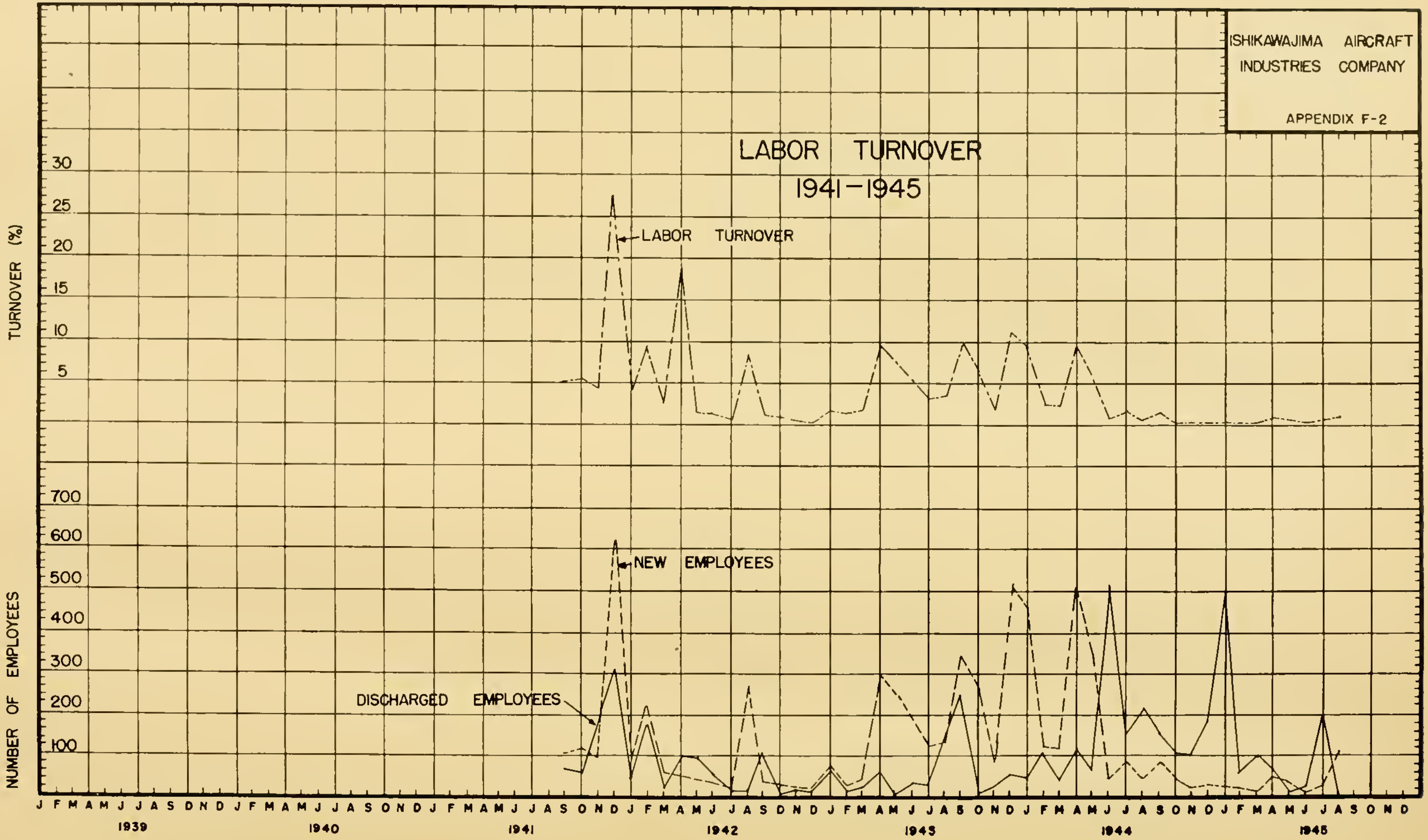


ISHIKAWAJIMA APPENDIX F-1

Labor turn-over

	New employees	Employees discharged	Turnover
1941			*Percent*
September	102	59	5.0
October	119	50	5.6
November	92	193	4.6
December	619	308	26.7
1942			
January	85	40	3.6
February	228	171	9.4
March	58	11	2.4
April	541	102	18.7
May	40	95	1.4
June	37	59	1.3
July	19	25	.7
August	269	9	8.7
September	35	108	1.2
October	27	3	.9
November	17	15	.6
December	13	7	.4
1943			
January	76	40	2.0
February	28	13	.9
March	48	24	1.5
April	297	45	9.7
May	244	2	7.4
June	183	30	5.3
July	120	24	3.4
August	133	147	3.8
1943			*Percent*
September	334	212	9.2
October	263	5	6.7
November	85	28	2.1
December	510	58	11.5
1944			
January	457	52	9.5
February	116	103	2.4
March	111	46	2.3
April	526	116	9.6
May	343	67	5.8
June	42	513	.7
July	88	152	1.5
August	44	211	.7
September	83	157	1.4
October	44	105	.7
November	21	99	.3
December	26	183	.4
1945			
January	25	508	.4
February	21	57	.3
March	10	102	.2
April	50	70	.9
May	35	7	.6
June	9	33	.2
July	28	209	.5
August	109	0	1.8

ISHIKAWAJIMA APPENDIX F-2



ISHIKAWAJIMA APPENDIX G

Dispersal data

Parent plant	Dispersal site	Nature of dispersal	Planned			Attained			Progress		Production activities
			Area (square feet)	Machine tools	Employees	Area (square feet)	Machine tools	Employees	Begun	Completed	
Tomioka	Chuetsu	Underground		225			225	454	December 1944	January 1945	Machining pistons and small parts.
	Sugita	do	49, 500	249		49, 500	86		July 1945	Not completed	Gear cutting.
	Negishi	do	139, 900	280		65, 700	135		do	do	Machining reduction gear casings and large parts.
	Sobū	do		123			123		do	July 1945	Machining cylinders.
	Yokosuka	do		78	99		78	99	do	do	Machining crankshafts.
	Sanuki	do		60			52	277	do	do	Machining connecting rods.
Hidaka	Chuetsu	do		200	500		137		June 1945	Not completed	Machining connecting rods and small parts.
	Tomioka	Main plant		100	250		41		do	do	Machining small parts.
	Sanuki	Underground					10		do	July 1945	Machining connecting rods.

ISHIKAWAJIMA APPENDIX H

Air attack data

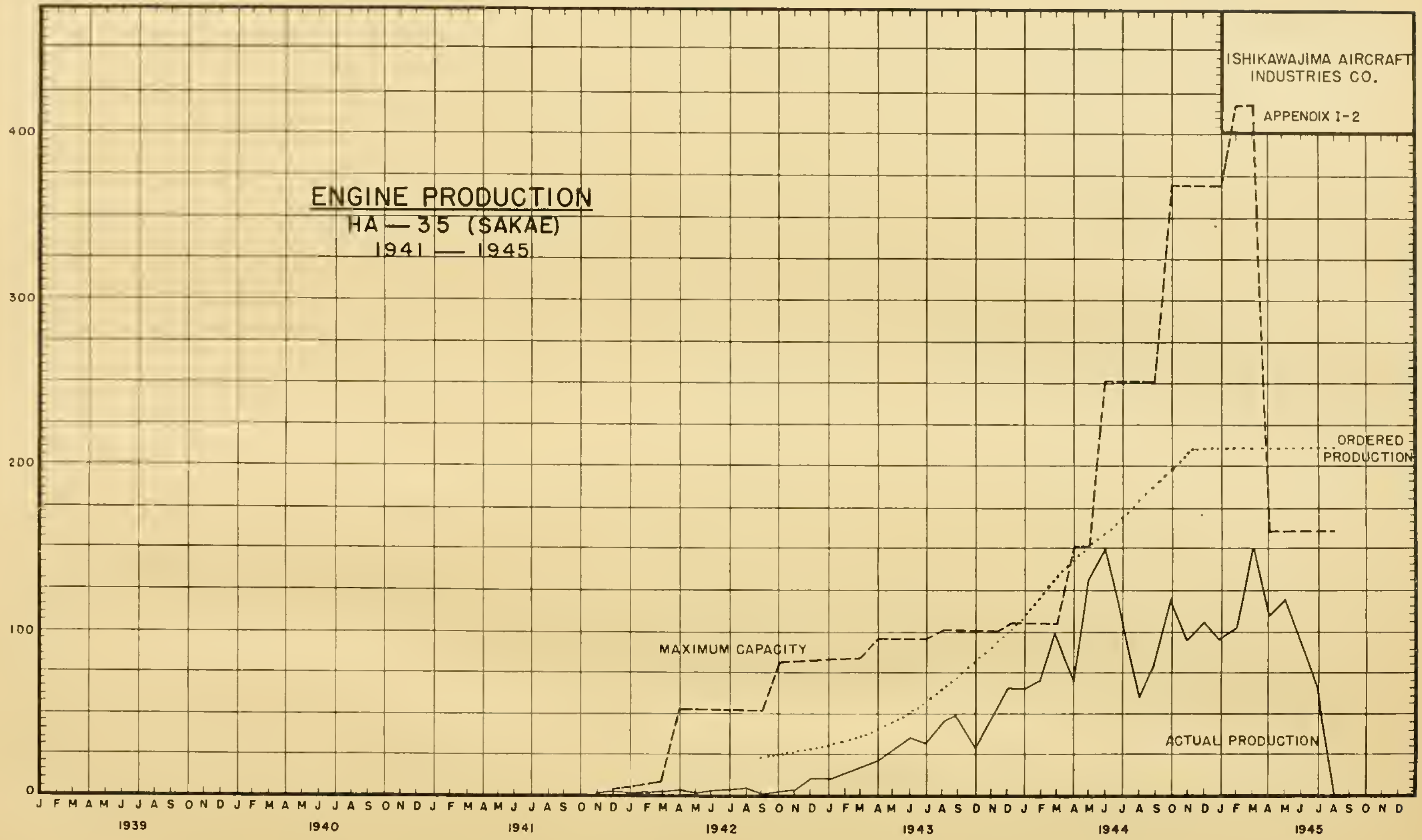
Date, attack air force, target	Installation damaged	Extent of damage	Materials damaged	Man-hours lost	Production loss
3 Apr. 1945, 20 AF, Kawasaki urban area.	Takashima Machi warehouse, Yokahama.	Warehouse burned; office and oil house damaged.	Cement stock, office supplies destroyed.	None	None.
15 Apr. 1945, 20 AF, Kawasaki urban area.	Nakamura-Bashi plant, Yokahama.	Office, warehouse, 1 shop building burned.	6 machines destroyed	9,120	None.
	Yawatabashi warehouse, Yokahama.	Warehouse and billet burned	Tools and instruments destroyed	None	None.
28 May 1945, 20 AF, Yokahama urban area.	Tomioka plant, Yokahama	No record	Gas supply system damaged	30,000	About 90 engines
	Suekichi warehouse, Yokahama.	Warehouse burned	Alloy steel stocks damaged		None.
	Takashima machine warehouse, Yokahama.	do	Graphite and cement stocks destroyed.	36,800	None.
	Sakurajieko warehouse, Yokahama.	do	Lead, zinc, tin, chemical stocks destroyed.		None.

ISHIKAWAJIMA APPENDIX I-1

HA-35 engine production November 1941–August 1945

	Actual	Ordered	Maximum
1941			
November	0		
December	1	5	
Total	1	5	
1942			
January	0	5	
February	0	7	
March	1	8	
April	2	50	
May	1	52	
June	3	52	
July	3	52	
August	5	52	
September	0	52	25
October	2	80	26
November	2	82	26
December	10	82	27
Total	29	574	104
1943			
January	10	82	30
February	12	82	33
March	16	82	35
April	20	95	40
May	27	95	45
June	35	95	50
July	32	95	60
August	45	100	70
September	50	100	70
October	30	100	80
November	48	100	90
December	65	105	100
Total	390	1,131	703
1944			
January	65	105	110
February	70	105	120
March	100	105	130
April	70	150	140
May	130	150	150
June	150	250	160
July	110	250	170
August	60	250	180
September	80	250	190
October	120	350	200
November	93	370	210
December	107	370	210
Total	1,155	2,705	1,970
1945			
January	95	370	210
February	101	420	210
March	150	420	210
April	110	160	210
May	118	160	210
June	91	160	210
July	67	160	210
August	0	160	210
Total	732	2,010	1,680

ISHIKAWAJIMA APPENDIX I-2



UNITED STATES STRATEGIC BOMBING SURVEY

LIST OF REPORTS

The following is a bibliography of reports resulting from the Survey's studies of the European and Pacific wars. Certain of these reports may be purchased from the Superintendent of Documents at the Government Printing Office, Washington, D. C. Permission to examine the remaining reports may be had by writing to the Headquarters of the Survey at Gravelly Point, Washington 25, D. C.

European War

OFFICE OF THE CHAIRMAN

1 The United States Strategic Bombing Survey: Summary Report (European War)
2 The United States Strategic Bombing Survey: Over-all Report (European War)
3 The Effects of Strategic Bombing on the German War Economy

AIRCRAFT DIVISION

(By Division and Branch)

4 Aircraft Division Industry Report
5 Inspection Visits to Various Targets (Special Report)

Airframes Branch

6 Junkers Aircraft and Aero Engine Works, Dessau, Germany
7 Erla Maschinenwerke G m b H, Heiterblick, Germany
8 A T G Maschinenbau, G m b H, Leipzig (Mockau), Germany
9 Gothaer Waggonfabrik, A G, Gotha, Germany
10 Focke Wulf Aircraft Plant, Bremen, Germany
11 Messerschmitt A G, Augsburg, Germany
    Over-all Report
    Part A
    Part B
    Appendices I, II, III
12 Dornier Works, Friedrichshafen & Munich, Germany
13 Gerhard Fieseler Werke G m b H, Kassel, Germany
14 Wiener Neustaedter Flugzeugwerke, Wiener Neustadt, Austria

Aero Engines Branch

15 Bussing NAG Flugmotorenwerke G m b H, Brunswick, Germany
16 Mittel-Deutsche Motorenwerke G m b H, Taucha, Germany
17 Bavarian Motor Works Inc, Eisenach & Durrerhof, Germany
18 Bayerische Motorenwerke A G (BMW) Munich, Germany
19 Henschel Flugmotorenwerke, Kassel, Germany

Light Metal Branch

20 Light Metals Industry of Germany
    Part 1, Aluminum
    Part II, Magnesium
21 Vereinigte Deutsche Metallwerke, Hildesheim, Germany
22 Metallgussgesellschaft G m b H, Leipzig, Germany
23 Aluminiumwerk G m b H, Plant No. 2, Bitterfeld, Germany
24 Gebrueder Giulini G m b H, Ludwigshafen, Germany
25 Luftschiffbau Zeppelin G m b H, Friedrichshafen on Bodensee, Germany
26 Wieland Werke A G, Ulm, Germany
27 Rudolph Rautenbach Leichmetallgiessereien, Solingen, Germany
28 Lippewerke Vereinigte Aluminiumwerke A G, Lunen, Germany
29 Vereinigte Deutsche Metallwerke, Heddernheim, Germany
30 Duerener Metallwerke A G, Duren Wittenau-Berlin & Waren, Germany

AREA STUDIES DIVISION

31 Area Studies Division Report
32 A Detailed Study of the Effects of Area Bombing on Hamburg
33 A Detailed Study of the Effects of Area Bombing on Wuppertal
34 A Detailed Study of the Effects of Area Bombing on Dusseldorf
35 A Detailed Study of the Effects of Area Bombing on Solingen
36 A Detailed Study of the Effects of Area Bombing on Remscheid.
37 A Detailed Study of the Effects of Area Bombing on Darmstadt
38 A Detailed Study of the Effects of Area Bombing on Lubeck
39 A Brief Study of the Effects of Area Bombing on Berlin, Augsburg, Bochum, Leipzig, Hagen, Dortmund, Oberhausen, Schweinfurt, and Bremen

CIVILIAN DEFENSE DIVISION

40 Civilian Defense Division—Final Report
41 Cologne Field Report
42 Bonn Field Report
43 Hanover Field Report
44 Hamburg Field Report—Vol I, Text; Vol II, Exhibits
45 Bad Oldesloe Field Report
46 Augsburg Field Report
47 Reception Areas in Bavaria, Germany

EQUIPMENT DIVISION

Electrical Branch

48 German Electrical Equipment Industry Report
49 Brown Boveri et Cie, Mannheim Kafertal, Germany

Optical and Precision Instrument Branch

50 Optical and Precision Instrument Industry Report

Abrasives Branch

51 The German Abrasive Industry
52 Mayer and Schmidt, Offenbach on Main, Germany

Anti-Friction Branch

53 The German Anti-Friction Bearings Industry

Machine Tools Branch

54 Machine Tools & Machinery as Capital Equipment
55 Machine Tool Industry in Germany
56 Herman Kolb Co, Cologne, Germany
57 Collet and Engelhard, Offenbach, Germany
58 Naxos Union, Frankfort on Main, Germany

MILITARY ANALYSIS DIVISION

59 The Defeat of the German Air Force
60 V-Weapons (Crossbow) Campaign
61 Air Force Rate of Operation
62 Weather Factors in Combat Bombardment Operations in the European Theatre
63 Bombing Accuracy, USAAF Heavy and Medium Bombers in the ETO
64 Description of RAF Bombing
64a The Impact of the Allied Air Effort on German Logistics

MORALE DIVISION

64b The Effects of Strategic Bombing on German Morale

Medical Branch

65 The Effect of Bombing on Health and Medical Care in Germany

MUNITIONS DIVISION

Heavy Industry Branch

66 The Coking Industry Report on Germany
67 Coking Plant Report No. 1, Sections A, B, C, & D
68 Gutehoffnungshuette, Oberhausen, Germany
69 Friedrich-Alfred Huette, Rheinhausen, Germany
70 Neunkirchen Eisenwerke A G, Neunkirchen, Germany
71 Reichswerke Hermann Goering A G, Hallendorf, Germany
72 August Thyssen Huette A G, Hamborn, Germany
73 Friedrich Krupp A G, Borbeck Plant, Essen, Germany
74 Dortmund Hoerder Huettenverein, A G, Dortmund, Germany
75 Hoesch A G, Dortmund, Germany
76 Bochumer Verein fuer Gusstahlfabrikation A G, Bochum, Germany

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